UDC 666.71:666.127.004.8

CERAMIC WALL MATERIALS USING GLASS WASTE

V. A. Leshina[1] **and A. L. Pivnev**[1]

Translated from Steklo i Keramika, No. 10, pp. 35 – 36, October, 2002.

The effect of glass waste on the properties of ceramic wall materials is investigated, the optimum batch composition is developed, and an experimental lot of bricks is produced on existing production lines without significant modifications of the technological conditions. The fundamental possibility of utilization of household waste glass is demonstrated.

In view of the deteriorating ecological situation in Russia and abroad, the problem of utilization of solid household waste, which keep occupying large areas, is very urgent. The interest in glass waste, whose share in solid household waste reaches 8 – 12%, has grown lately in Russia. Glass waste remains resistant to atmospheric precipitation for many years; therefore, its storage on urban dumping areas is economically ineffective [1].

The absence of scientific substantiation of the cullet-utilization program makes each region look for its own approach to the problem. A regional program of utilization of household waste was developed in the Vladimir Region in the end of 1990s. The program included an experiment of separate collection of household waste in containers painted in different colors. The bulk of waste glass in household waste was represented by glass bottles of different colors.

The present study investigates the possibility of using waste container glass in the production of bricks regularly produced at the Vladimir Ceramic Products Works (VCPW) without significant modification of the existing technological regulations. The effect of cullet on the main properties of ceramic wall materials was investigated on experimental samples molded as disks and fillets by semidry molding under a pressure of 30 MPa with exposure at the maximum temperature for 3 – 5 sec, which correlated with the brick-molding pressure used at the VCPW.

The studies were based on standard VCPW batch containing 97.0 – 97.5% milled clay (moisture 9 – 11%), 2.5 – 3.0 vol.% coal slime from the Cherepovets Metallurgical Works, and 1.5% broken brick (above 100% batch). According to GOST 9169–75, the clay is low-melting (its refractory index is 1270°C), moderately plastic, highly sensitive to drying, with respect to its Al_2O_3 content in the calcined state (13.55%) it is classified as acid clay, and the quantity of organic inclusions is 0.69%, 0.33% CO_2, and 3.76% H_2O.

Container glass cullet was subjected to a thermal shock, dried at a temperature of 110°C, then milled in a ball mill for 30 min (the weight ratio of milling bodies to glass was equal to 3 : 1). Milled glass was screened by fractions: below 0.14, 0.14 – 0.315, 0.315 – 0.63, and 0.63 – 1.4. The amount of introduced cullet varied within the limits of 5 to 30 wt.% (above 100% batch).

The samples were fired in industrial and laboratory furnaces for 36 h with a 4-h exposure at the firing temperature of 980°C. Samples with a high content of the coarse fraction of glass became deformed, accordingly, they were not analyzed. In other samples the shrinkage coefficient, water absorption (GOST 7025–78), bulk density (GOST 6427–75), bending strength (GOST 8462–85), and thermal conductivity (GOST 7076–87) were determined.

The physicomechanical properties of samples of wall material containing 5 – 30% cullet are indicated in Fig. 1 after mathematical processing of results. The increase in the cullet content in samples up to 20% results in a sharp increase in the bulk density; as the cullet content grows to 30%, the bulk density varies insignificantly. The strength of the samples increases as well. A jumplike increase in compression strength is observed in samples containing glass power with particle size of 0.140 – 0.315 mm. The water absorption of samples decreases from 10.9 – 12.3 to 7.5 – 8.2% depending on the glass power fraction, and the thermal conductivity grows with increasing cullet content; however the increment in the thermal conductivity measured on samples of different fractions decreases.

It is established that the optimum content of cullet in a ceramic mixture is 15 – 20%, which makes it possible to produce ceramic wall materials meeting the requirements of the state standards regarding water absorption (for solid brick at least 8% and hollow brick at least 6%) with improved me-

[1] Vladimir State University, Vladimir, Russia.

0361-7610/02/0910-0356$27.00

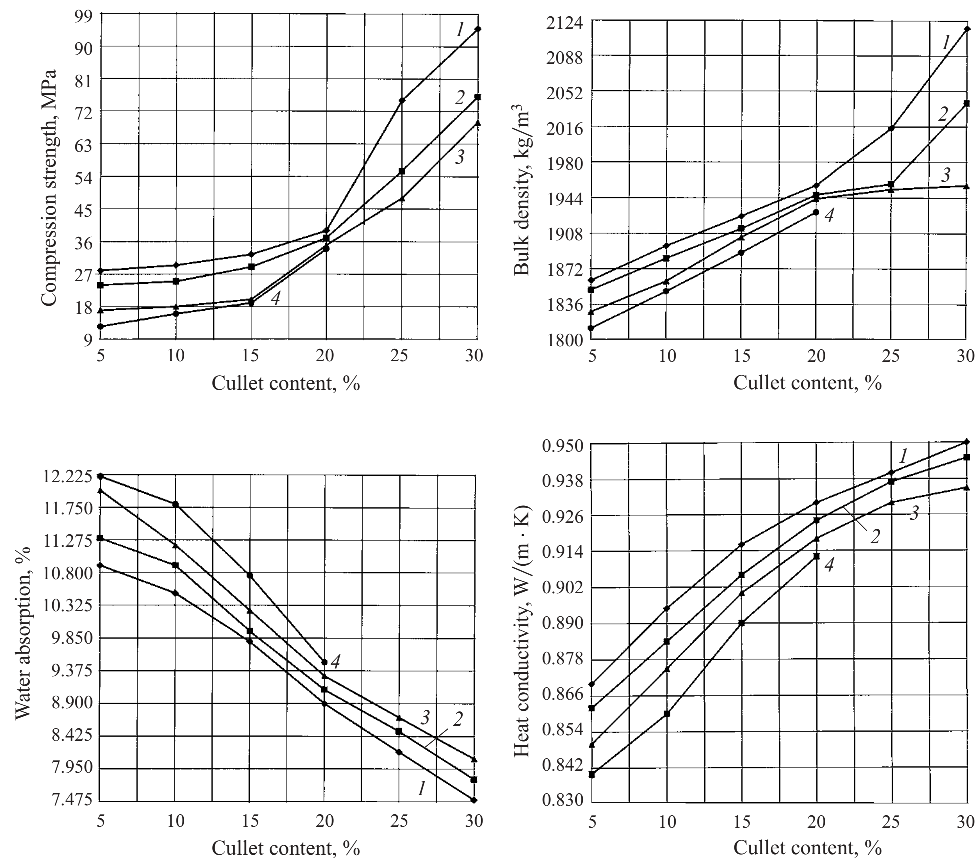

Fig. 1. Dependence of physicomechanical properties of ceramics samples on the cullet content: *1*, *2*, *3*, and *4*) cullet fractions of sizes below 0.14, 0.14 – 0.315, 0.315 – 0.63, and 0.63 – 1.4 mm, respectively.

chanical properties. This result was used in preparing batch for solid bricks at the VCPW.

A batch of bricks was prepared using the proposed formula with 20% cullet additive (above 100%), which experiences drying and firing under industrial conditions. The experimental batch contained cullet of mixed fractions, up to a size of glass fragments equal to 5 – 10 mm.

The physicomechanical characteristics determined for fired bricks were the same as those determined for samples, and in addition cold resistance was found using the fast method. For this purpose a standard solution of sodium sulfate was prepared with the ratio of 250 g Na_2SO_4 per liter of water. Sodium sulfate in small portions was dissolved in water preheated to 30°C, the solution being constantly stirred. The prepared solution was cooled to room temperature and left to settle for 24 h. Then the solution was decanted, a sample was immersed into the solution to saturate for 20 h, then dried at temperature of 100 – 110°C for 4 h. After that the sample again was immersed in the solution for 4 h and then inspected. The testing continued until the sample started to crumble.

The determination of cold resistance using this method is especially drastic, since crystals of sodium sulfate decahydrate $Na_2SO_4 \cdot 10H_2O$ are formed in the pores of the materials and exert a stronger pressure on the pore walls than water in freezing. Therefore, one cycle of testing in sodium sulfate solution is assumed equal to 10 cycles of freezing in water. The cold resistance of the brick was no less than 70 cycles.

The physicomechanical properties of brick with 20% cullet additive after mathematical processing were correlated with the respective properties of the reference brick of grade 100 produced at the VCPW (Table 1).

Factory-made brick of grade 100 is significantly inferior in physicomechanical properties to brick with the cullet addi-

TABLE 1

Parameter	Brick	
	with glass cullet	VCPW, grade 100
Density, kg/m^3	1988 ± 25	1950
Water absorption, %	9.4 ± 0.5	At least 8
Strength, MPa:		
bending	4.1 ± 0.5	1.6
compressive	28.1 ± 0.5	10
Thermal conductivity, W/(m · K)	0.93 ± 0.01	0.91
Cold resistance, cycles	At least 70	At least 15

tive. The glass additive increases the amount of the liquid phase in the material, which decreases its porosity and water absorption and increases its mechanical strength.

Thus, household waste glass can be used in existing technologies of ceramic wall materials, adding the operations of thermal shock and milling on available equipment. The utilization of glass waste substantially reduces dumping-site space, which has a great significance in environmental protection.

REFERENCES

1. N. I. Min'ko, V. N. Bolotin, and N. F. Zhernovaya, "Technological, energy, and environmental aspects of collection and use of cullet," *Steklo Keram.*, No. 5, 3 – 5 (1999).